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ABSTRACT

This study was undertaken for the Center for Applied Linguistics to survey and analyze its information system program for the language sciences. The study identifies and defines the generalized sets of parameters required for subsequent quantitative analysis of proposed alternative Language Information Network and Clearinghouse Systems by means of mathematical models. The report describes the descriptive and evaluative models characterizing the information system in operational terms and expresses the relationship between measures of value or effectiveness and cost, and the chosen alternative designs. Variables defining alternative systems and parameters affecting system effectiveness are presented. The structure of the descriptive model characterizing a generalized conceptual information system is drawn. Variables and parameters of the system user community are described. Characterization of information elements and processing from real-world inputs to service outputs is developed. Cost parameters required to evaluate system operating costs are presented for materials, processing and communications. A summary list of symbols follows. The report recommends specification of system variables, design of data forms, data reduction, development of an evaluative model, and tailoring of a descriptive model. (CHK)

CENTER FOR APPLIED LINGUISTICS

LANGUAGE INFORMATION NETWORK AND CLEARINGHOUSE SYSTEM (LINCS)

PARAMETER REQUIREMENTS FOR DESCRIPTION OF ALTERNATIVE LINC SYSTEMS

By Information Dynamics Corporation

LINCS PROJECT DOCUMENT SERIES / NATIONAL SCIENCE FOUNDATION GRANT
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CENTER FOR APPLIED LINGUISTICS, 1717 MASSACHUSETTS AVENUE, N.W., WASHINGTON, D.C. 20036

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PARAMETER REQUIREMENTS
FOR DESCRIPTION OF
ALTERNATIVE
LINC SYSTEMS

Final Report to:

Center for Applied Linguistics
1717 Massachusetts Avenue, N.W.
Washington, D.C. 20036

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March 20, 1968

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I. INTRODUCTION

A. General

This study was performed under Ltr. Contract CAL dated December 12, 1967, Reference P-8628 for the Center for Applied Linguistics, 1717 Massachusetts Avenue, N.W., Washington, D.C. The study was undertaken as part of a broader effort of the Center for the SURVEY-AND-ANALYSIS STAGE of the INFORMATION-SYSTEM PROGRAM FOR THE LANGUAGE SCIENCES.

The Center's information-system program is designed to provide for development activities aimed at the technical specification and pilot study of essential system requirements. The SURVEY-AND-ANALYSIS STAGE of this program concentrates on the essential preliminaries of the program: Planning Approaches and System Component Studies. In support of these preliminary efforts, the study contained herein is oriented toward the analysis required to identify and describe the relevant parameters required for subsequent analysis of proposed alternative systems by means of mathematical models.

B. Purpose of Study

The purpose of this study is to identify and define the generalized sets of parameters whose values are required for subsequent quantitative analysis of proposed alternative Language Information Network and Clearinghouse Systems (LINCS) by means of mathematical models. In addition, the defined parameters can serve as guidelines for the data collection and data banking efforts in the SURVEY-AND-ANALYSIS STAGE.

C. Scope of Study

This study is limited to consideration of the parameters to be associated with the linguistics community, linguistics literature items, and a generalized

LINC system. The study effort is primarily based on information obtained from a previous study conducted by Information Dynamics Corporation (IDC), titled, "A Methodology for the Analysis of Information Systems", Contract NSF-C-370.

D. Background

The Center for Applied Linguistics is currently conducting a survey and analysis of the information system for the language sciences. This stage of the Center's study effort is addressed to the preliminary qualitative and quantitative analysis required for advanced studies in the design of a LINC system.

A portion of the advanced studies will be concerned with the detailed formulation and quantitative analysis of alternative LINC systems. It is planned that the quantitative analysis will be conducted with the aid of a mathematical model similar to the one described in IDC report, "A Methodology for the Analysis of Information Systems". The model described in the above report is designed to facilitate the study and evaluation of operating costs for alternative information service network configurations.

Prior to the detailed quantitative analysis of alternative systems, preliminary analyses are required to (1) formulate alternative systems (2) identify the parameters associated with the alternative systems and (3) estimate the values of the parameters. The analysis presented in the following sections is primarily addressed to the identification of sets of parameters associated with a generalized LINC system.

II. QUANTITATIVE EVALUATION REQUIREMENTS

A. Introduction

As indicated in the previous section, a portion of the advanced studies will be addressed to the quantitative evaluation of alternative LINC systems. In order to formulate a basis for further discussion of the relevant system parameters, this section presents the general form of the evaluation model and, as a consequence, the evaluation activities that must be performed in the quantitative evaluation process.

B. Evaluation Model

The quantitative evaluation process requires the use of two models which we will call a "descriptive model" and an "evaluation model". The descriptive model characterizes the information system in terms of the specific operational processes that govern the cause and effect relationships. For example, the model described in IDC Report, "A Methodology for the Analysis of Information Systems", is of this type. The evaluation model expresses the relationship between the measures of value or effectiveness and cost, and the chosen alternative designs.

In accordance with the objectives of the quantitative evaluation, the model for the evaluation of alternative LINCS systems takes on the general form:

$$(1) \quad \begin{cases} V_i = f_1 (X_i, Y_i), \\ C_i = f_2 (X_i, Y_i) = f_3 (V_i), \text{ or } V_i = f_4 (C_i) \end{cases}$$

where V_i = the measure of value or effectiveness of the i-th alternative system.

C_i = the relative cost of the i-th alternative system.

X_i = the parameters (variable or constant) which affect system system performance or costs but which are not subject to control by the systems designers.

Y_i = the variables which define the alternative systems and which are subject to control by system designers.

f_1 = the functional relationship between the parameters and independent variables, X_i and Y_i, and the dependent variable V_i.

f_2 = the functional relationship between the parameters and independent variables, X_i and Y_i, and the dependent variable C_i.

In descriptive terms, the evaluation model or process has the following essential characteristics. First, one set of input data, denoted by Y_i, is subject to control by system design .rs. This set of data defines the elements of the system which are directly controlled by designers and would include, for exa ple, such elements as the types of product. and services to be made available to the user community. Second, for each alternative system, there exists a set of data (parameters), denoted by X_i, which is not subject to control. For example, if a particular mode of communication is chosen, then the communication cost rates are not subject to control by system designers. Third, the output variables, V_i and C_i, are relative measures of value or effectiveness and cost for use in the evaluation process.

For purpose of evaluation and comparison, the dependent variables associated with a specific set of variables and parameters, and therefore alternative systems designs, may be graphically represented by a two-dimensional outcome space as indicated in Figure II-1.

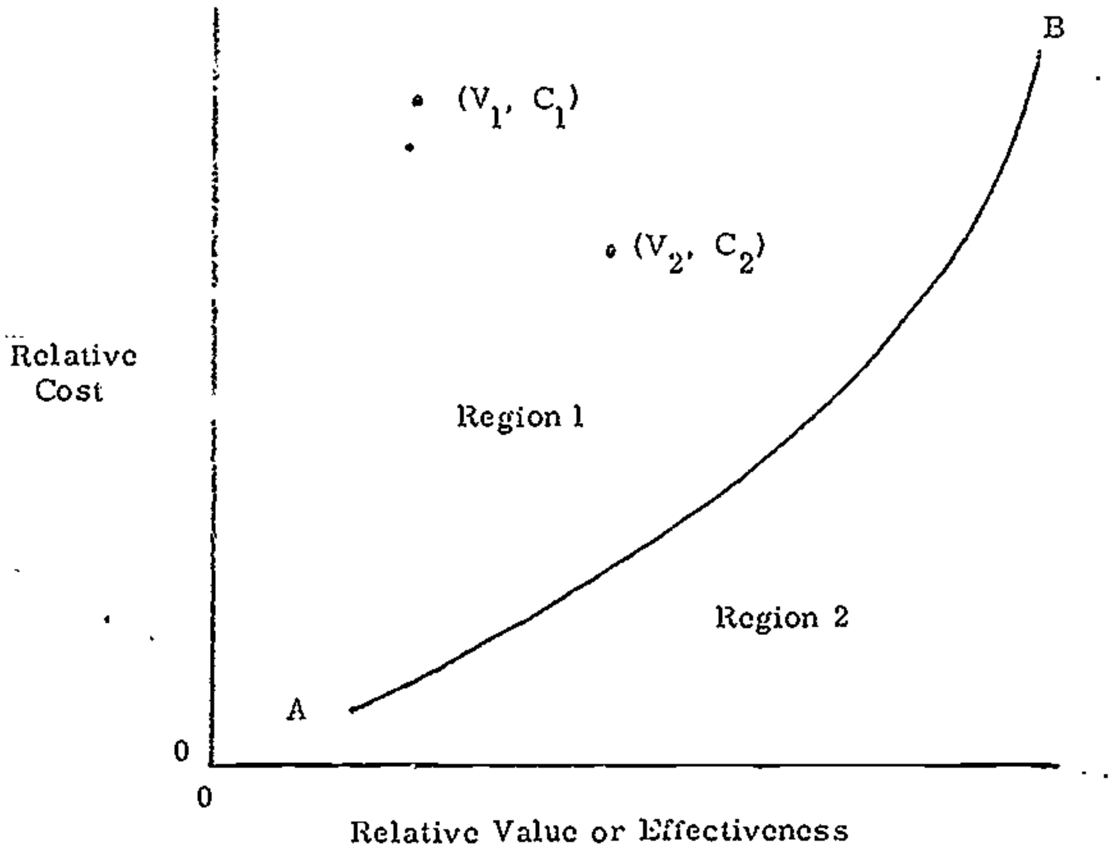

Figure II-1. Outcome Space

Each point plotted in the outcome space represents a specific alternative design. In the above illustration, two alternative designs are represented above the curve AB. All possible points associated with design alternatives would be contained in Region 1 (above the curve AB) and no alternative designs would appear in Region 2 (below the line AB). Optimal alternative designs would fall on the curve AB.

Having identified the general form of the evaluation model and the different classes of inputs and outputs, the following section discusses the activities to be performed in the quantitative evaluation process.

C. Evaluation Activities

Within the context of the evaluation model, the objectives of the quantitative evaluation process may be stated as follows:

1. Identify optimal alternative LINC systems (i. e., the systems that fall on the curve AB shown in Figure II-1).
2. Evaluate optimal systems and choose a particular system design.

The study activities required to meet these objectives are best presented as they affect the components of the evaluation model. These activities are illustrated in Figure II-2. This description of the evaluation process implies that the above objectives will be achieved by the careful updating and refining of the various inputs to the model and subsequent re-evaluations.

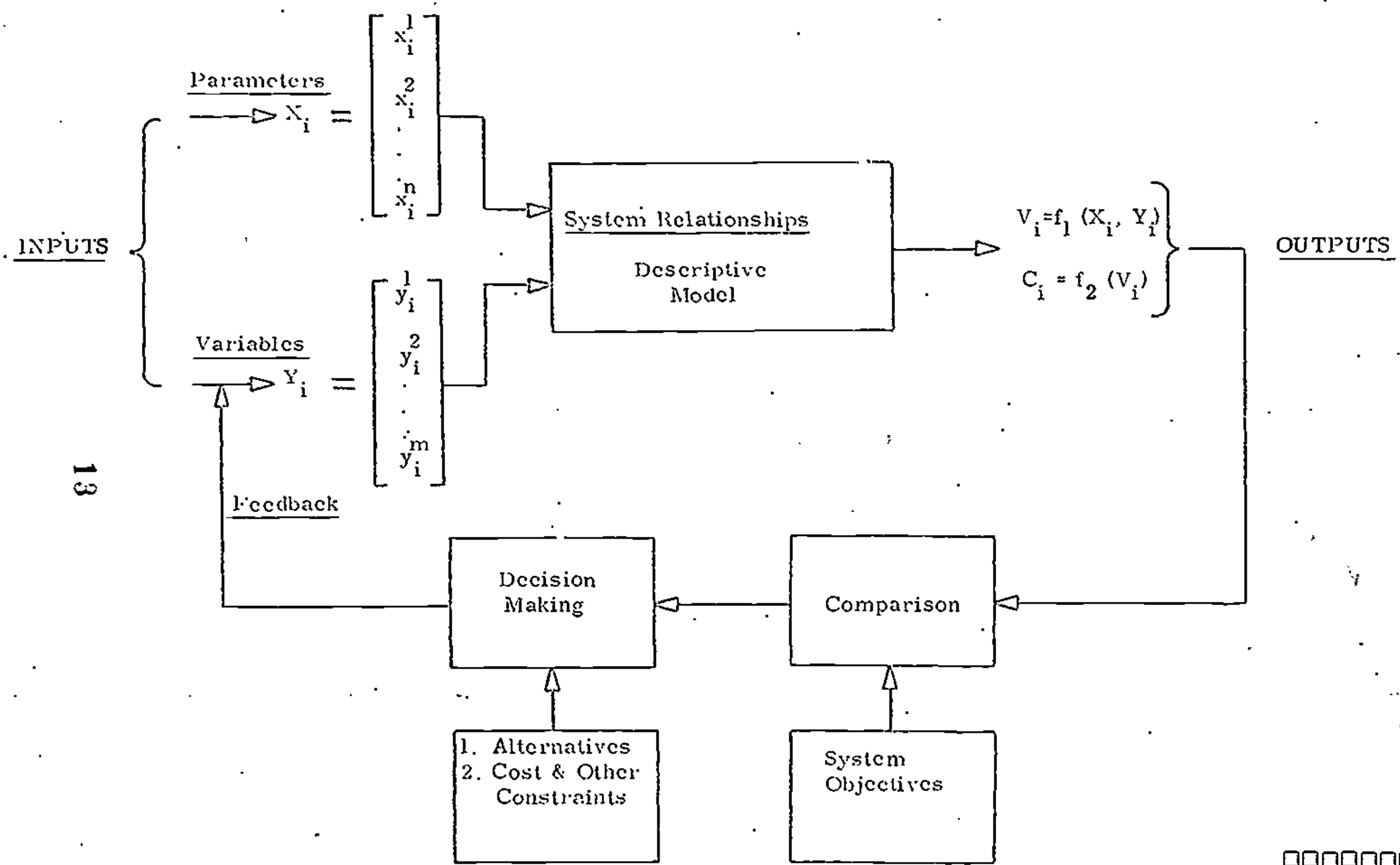

Figure II-2. LINC System Evaluation Activities

The following are the necessary implementation functions:

1. Evaluation of Inputs - Inventories of input parameters and variables will have to be maintained for the specification and subsequent evaluation of alternative LINC systems. This would include the identification and evaluation of variables such as literature sources, literature items, services and products, system components and the user community. Parameters associated with the variables would have to be identified and, making use of the best data available, their values estimated. Computer analysis of the data in addition to a computer aided inventory system would greatly facilitate the evaluation process.
2. Evaluation of Cost-Effectiveness Relationships - In order to compare the various alternative systems designs with the CAL INFORMATION-SYSTEM PROGRAM objectives, the cost-effectiveness relationships for various alternative designs would have to be estimated. It will be necessary to construct this model. The model would be of the general form described in Section II-B, Evaluation Model. The development of this model would require a detailed review of program objectives to determine the measures of value or effectiveness to be employed.
3. Evaluation of Outputs - The cost-effectiveness relationships of alternative designs would have to be compared to the CAL program objectives as a measure of success of the program. This evaluation would also include continuous evaluation and possible modification of program objectives.

4. Evaluation of Alternatives and Constraints - Alternative systems designs will have to be formulated or modified making use of the best technical data available, the program objectives and knowledge of whatever constraints that exist. Included in the formulation process would be the identification of the input variables and parameters which describe each alternative system design.

D. Concluding Remarks

In this section, the basic requirements for the quantitative evaluation of alternative LINC systems are structured in order to set the context for discussion of relevant information system parameters. Of particular importance to the study contained herein is the concept of two sets of input data which are

1. the variables which define alternative systems and which are subject to control by system designers, and
2. the parameters (variable or constant) which affect system effectiveness or value and costs but which are not subject to control by systems designers.

The selection of a particular set of variables identifies and defines a specific information system design and fixes, in the mathematical sense, the effectiveness or value and cost associated with the design.

The above two classes of data are input to a "descriptive model" which characterizes the information system in terns of cause and effect relationships. The outputs of the above model are then employed to estimate the cost-effectiveness or value relationships for various alternative designs.

Since the study addressed herein is primarily concerned with the identification of parameters which will be input to the descriptive model, the following section presents a brief discussion of its structure.

III. DESCRIPTIVE MODEL STRUCTURE

A. Introduction

This section presents the structure of the descriptive model which characterizes a generalized conceptual information system. The purpose of the presentation is to identify the classes of elements or components of the conceptual system which are explicitly accounted for by the descriptive model.

From the point of view of the descriptive model, the conceptual elements explicitly accounted for are defined in terms of two sets of input data (variables and parameters) as defined in the preceding section. This section also identifies the classes of variables which are employed to define alternative systems and the associated parameters which are required as inputs to the descriptive model.

B. The Generalized Conceptual Model

The classes of elements or components of a generalized conceptual information are illustrated in Figure III-1. The classes of elements explicitly accounted for by the descriptive model are

1. the user community,
2. the system output services,
3. the information system centers, including processes and communications links, and
4. the information inputs.

These elements are identified by solid lines in Figure III-1. Elements identified by dashed lines are implicitly accounted for by the descriptive model.

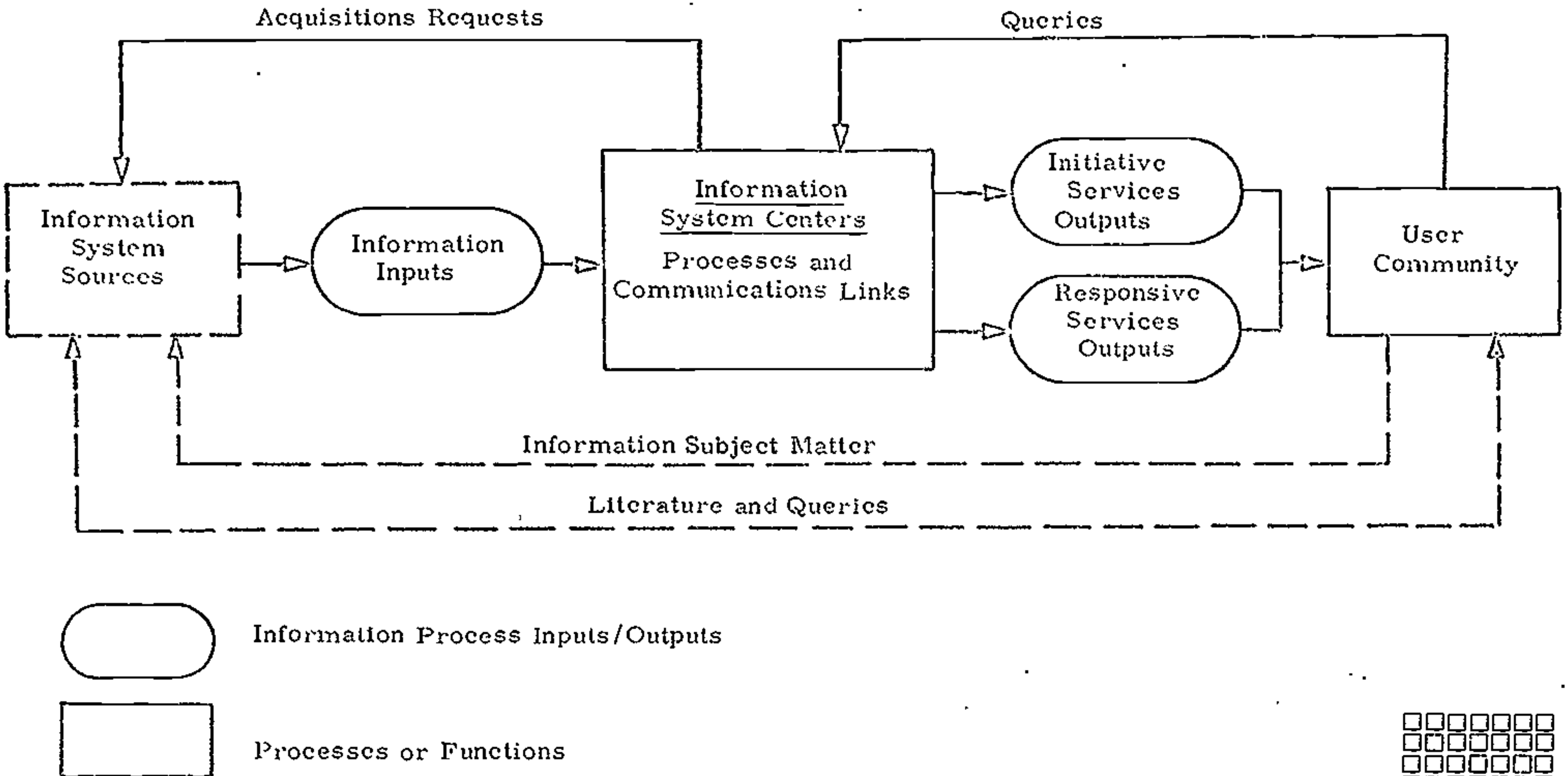

Figure III-1. Conceptual Model of a Generalized Information System.

From the viewpoint of the descriptive model, the generalized conceptual information system may be described as follows:

INFORMATION OUTPUTS - The information system center(s) must provide and distribute information services and products based upon the needs of the user community. Two broad classes of services and products are identified which are, "initiative services outputs" and "responsive services outputs". Initiative services are those services provided automatically at equal intervals of time (i.e. once a month, etc.). Responsive services are those services provided upon request from a member of the user community.

INFORMATION INPUTS - In order to provide information service outputs, the information center(s) must acquire information packages occurring in the environment corresponding to the two types of service outputs.

INFORMATION CENTERS; PROCESSES - The system must extract and communicate from the information packages it acquires those elements of information it must process. It must also maintain a store of information elements and process the stored information to provide information outputs.

Within the above conceptual structure, a large number of alternative systems designs could be erected and quantitatively studied. The erection of alternative systems designs is accomplished by providing sets of definitions and choices of variables associated with each of the above elements explicitly accounted for by the descriptive model.

C. Characterization of Alternative Systems

As indicated previously, the alternative systems are characterized in terms of two sets of input data which we called variables and parameters. This characterization is accomplished first by defining and choosing the variables which characterize the alternative systems and then estimating the values of parameters associated with the variables.

The specification of variables requires the following:

1. Definition and choice of elements of the user community to be served.
2. Definition and choice of initiative and responsive services to be provided.
3. Definition and choice of information inputs.
4. Definition and choice of processing operations.
5. Definition and choice of network structure.
6. Definition and choice of communications carriers.

In order to quantitatively evaluate various alternative designs, the following parameters would have to be estimated making use of the best available data.

1. User Community
   a. population
   b. bias of interest
   c. regional distribution

2. Information Inputs/Outputs
   a. quantities
   b. flow rates
   c. materials costs

3. Processes
    a. manhours required by process operation
    b. manhour wage rates

4. Communications
    a. distances
    b. volumes
    c. costs

Having defined the general properties of alternative information systems accounted for by the descriptive model, we now turn our attention to the detailed variable and parameter requirements.

IV. CHARACTERIZATION OF THE USER COMMUNITY

The properties of the user community are basic to the design of the system since they directly or indirectly affect all other components of the system. This section presents the variables and parameters required to characterize the user community.

A. User Community Variables

For the purposes of this study, the user community is defined as a set of individuals to be served by an information service center (or centers). These individuals are categorized according to

1. a set of defined subject disciplines,
2. a set of defined geographic regions, and
3. a set of defined projects/missions.

Two classes of information service centers may be considered, which are

1. the direct-service center, and
2. the "clearing house" or pre-processing center.

The above classification of individuals and service centers requires the determination of the variables which follow:

N(C) = the number of subject disciplines.

N(R) = the number of geographic regions.

N(D) = the number of projects/missions.

C_r = the identification of the r-th discipline, $r=1, 2, \ldots, N(C)$.

R_s = the identification of the s-th geographic region, $s=1, 2, \ldots, N(R)$.

D_i = the identification of the i-th project/mission, i=1, 2, . . . , N(D).

N(K) = number of direct service centers.

K_o = the identification of the "clearing house" center.

K_r = the identification of the r-th direct service center.

B. User Community Parameters

After the determination of the variables associated with the above classification scheme, the following parameters would have to be estimated:

$X(C_r, D_i)$ = estimated number of individuals associated with the i-th project/mission and the r-th subject discipline.

$X(C_r, R_s)$ = estimated number of individuals associated with the r-th subject discipline and located in the s-th geographic region.

$\beta^1(D_m, D_i)$ = estimated average number of individuals associated with the i-th project/mission that are interested in the m-th project/mission.

$\beta^1(D_m, D_i) = 1$ for m = i and

$0 \leq \beta^1(D_m, D_i) \leq 1$ for $m \neq i$.

$X(C_r)$ = estimated number of individuals associated with the r-th subject discipline where

$$X(C_r) = \sum_{i=1}^{N(D)} X(C_r, D_i).$$

$D(K_o, K_r)$ = estimated distance from the clearing house center to the r-th direct service center.

$D(K_r, R_s)$ = estimated distances from the direct service centers to centroid of the population in the s-th geographic region.

In order to facilitate the estimation of parameter values and the analysis of variables and parameters, it is recommended that the sets of parameter values be recorded in the form of two-way tables as shown below:

C_r \ D_i	1	2	.	.	.	N(D)
1						
2						
.		$X(C_r, D_i)$				
.						
.						
N(C)						

C_r \ R_s	1	2	.	.	.	N(R)
1						
2						
.						
.		$X(C_r, R_s)$				
.						
N(C)						

$D_m \backslash D_i$	1	2	. . .	$N(D)$
1	1			
2		1	$\beta^1(D_m, D_i)$	
.				
.				
.				
$N(D)$				1

$K_r \backslash R_s$	1	2	. . .	$N(R)$
1				
2				
.		$D(K_r, R_s)$		
.				
.				
$N(K)$				

V. CHARACTERIZATION OF INFORMATION ELEMENTS

The nature of the service outputs and information inputs is of importance since it will determine to a large extent the kinds of system processes required. In this section, the characterization of information elements from real-world inputs to service outputs is developed.

A. Categories of Information Elements; System Processes

The major categories of information are developed based upon three main groups of processes which the system must contain. These groups are:

1. Acquisition processing consisting of all those operations and activities necessary for acquiring real-world information input and converting it for further processing.
2. Input processing by which the basic stores of information are created.
3. Output processing through which the services and output services are generated from the system stores.

By ordering these main groups of processes as shown in Figure V-1, we can now identify five categories of information elements which are as follows:

1. Real-World Inputs, $\{I_j\}$ - Information packages entering the system processes in the form of their occurrance in the system environment. Examples of real-world inputs are issues of journals, monographs, abstract journals, etc.
2. Input Information Elements, $\{I_r\}$ - Those elements of information obtained from the "information packages" entering the system processes. Examples of input information elements are individual journal articles, entire monographs, single bibliographic citations, etc.

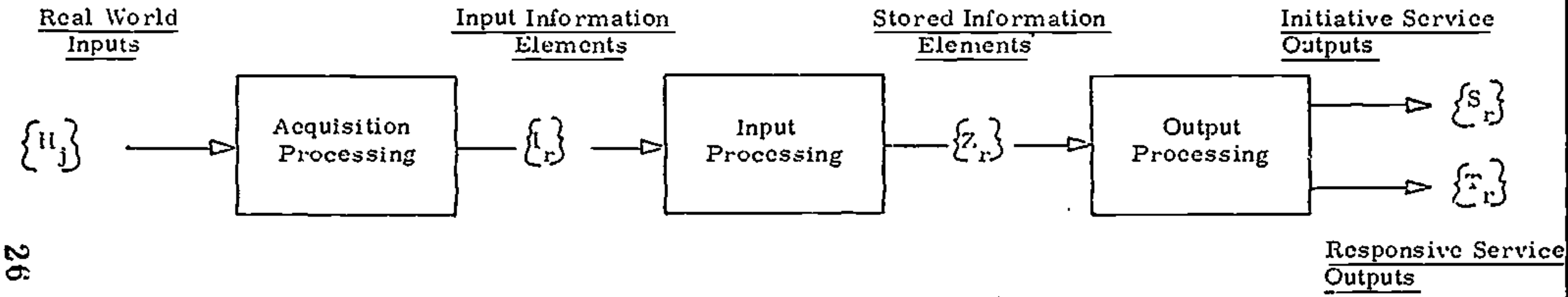

Figure V-1. Categories of Information Elements

3. Stored Information Elements, $\{Z_r\}$ - Those elements of information obtained from input information elements and placed in the system stores. For example, bibliographic descriptions, descriptive abstracts, etc.
4. Initiative Service Outputs, $\{S_r\}$ - The types of services to be made available to the user community automatically at equal intervals of time. For example, announcement lists, catalog and index, research in progress, etc.
5. Responsive Service Outputs, $\{T_r\}$ - The types of services to be made available to the user community upon request. For example, directorial services, specific search and retrieval, etc.

Having defined the categories of information to be considered, we now turn our attention to the sets of variables and parameters required to categorize them.

B. Information Element Variables

In order to characterize the information elements and their interrelationship in the system design, the following variables will require identification:

N(II) = the number of categories of "real-world inputs".

N(I) = the number of categories of "input information elements".

N(Z) = the number of categories of "stored information elements".

N(S) = the number of categories of "initiative service outputs".

N(T) = the number of categories of "responsive service outputs".

H_j = the identification of the j-th type of real world input, $H_j = 1, 2, \ldots,$ N(II

I_r = the identification of the r-th type of input information element, $I_r = 1, 2, \ldots, N(I)$.

Z_r = the identification of the r-th type of stored information element, $Z_r = 1, 2, \ldots, N(Z)$.

S_r = the identification of the r-th type of initiative service outputs, $S_r = 1, 2, \ldots, N(S)$.

T_r = the identification of the r-th type of responsive service outputs, $T_r = 1, 2, \ldots, N(T)$.

C. Relationships Between Variables

The next step in the characterization of the information elements is the identification of the relationships among the information elements and between the information elements and the user community. This can best be presented in the form of two-way tables which indicate whether or not a relationship between elements of information and/or the user community exists. An entry of "1" in the tables indicates the existance of a relationship, an entry of "0" indicates a relationship does not exist.

$[D_i, H_j]$ = binary relationship between the user community projects/missions D_i and the types of real world inputs H_j.

D_i \ H_j	1	2	.	.	.	N(H)
1						
2	values of either "0" or "1"					
.						
.						
.						
N(D)						

$[H_j, I_r]$ = binary relationship between the real world inputs H_j and the input information element I_r.

$H_j \backslash I_r$	1	2	. . .	N(I)
1				
2	values of either "0" or "1"			
.				
.				
.				
N(H)				

$[I_r, Z_r]$ = binary relationship between input information elements I_r and stored information elements Z_r.

$I_r \backslash Z_r$	1	2	. . .	N(Z)
1				
2	value of either "0" or "1"			
.				
.				
.				
N(I)				

$[Z_r, S_r]$ = binary relationship between stored information elements Z_r and initiative service outputs S_r.

Z_r \ S_r	1	2	.	.	.	N(S)
1						
2	values of either "0" or "1"					
.						
.						
.						
N(Z)						

$[S_r, D_i]$ = binary relationship between initiative service outputs S_r and user community projects/missions D_i.

S_r \ D_i	1	2	.	.	.	N(D)
1						
2	values of either "0" or "1"					
.						
.						
.						
N(S)						

$[T_r, D_i]$ = binary relationship between responsive service outputs T_r and user community projects/missions D_i.

T_r \ D_i	1	2	.	.	.	N(D)
1						
2	values of either "0" or "1"					
.						
.						
.						
N(T)						

D. <u>Information Element Parameters</u>

This section identifies and defines the flow rate parameters to be associated with the variables that describe the information elements. The estimated values of these parameters should be recorded in the tabular forms indicated after each definition.

The parameters requiring estimation are defined as follows:

$Y(D_i, H_j)$ = the estimated mean number of real world inputs of type H_j generated by the project/mission of type D_i per unit time (i.e., per month).

D_i \ H_j	1	2	.	.	.	N(H)
1						
2						
.						
.	Values of $Y(D_i, H_j)$					
.						
N(D)						

a_{jr}' = the estimated mean number of units of input information elements of type I_r derived from a real world input of type H_j.

H_j \ I_r	1	2	.	.	.	N(I)
1						
2						
.	Values of a_{jr}					
.						
.						
N(H)						

b_{jr} = the estimated mean number of units of stored information elements of type Z_r derived from an input information element of type I_j.

I_j \ Z_r	1	2	.	.	.	N(Z)
1						
2	values of b_{jr}					
.						
.						
.						
N(I)						

c_{jr} = the estimated mean number of initiative service outputs of type S_r derived from a stored information element of type Z_j.

Z_j \ S_r	1	2	.	.	.	N(S)
1						
2						
.	values of c_{jr}					
.						
N(Z)						

p_{jr} = the estimated percentage of the population of project/mission type D_r to receive service outputs of type S_j.

S_j \ D_r	1	2	.	.	.	N(D)
1						
2		values of p_{jr}				
.						
.						
.						
N(S)						

$\bar{p}_{jr}$ = the estimated number of requests for responsive outputs of type T_r per member of the D_i project/mission per unit of time.

D_i \ T_r	1	2	.	.	.	N(T)
1						
2		values of $\bar{p}_{jr}$				
.						
.						
.						
N(D)						

VI. CHARACTERIZATION OF PROCESSING FUNCTIONS

A. Introduction

In the preceding section, three main groups of processes were identified:

1. Acquisition processing.
2. Input processing.
3. Output processing.

For purposes of evaluation, the above categories of processes are assumed to be composed sets of operations which are required to perform the transformations on the information elements identified in the preceding section. This section identifies and defines the variables and parameters required to characterize these operations which, in turn, characterize the three groups of processes.

B. Process Variables

In order to characterize the three groups of processes, the following variables must be identified:

$N(G^1)$ = the number of operations associated with the acquisition processing function.

$N(G^2)$ = the number of operations associated with the input processing function.

$N(G^3)$ = the number of operations in the output processing function associated with initiative service outputs.

$N(G^4)$ = the number of operations in the output processing function associated with responsive service outputs.

G_i^1 = the identification of the i-th operation associated with the acquisition processing function, $G_i^1 = 1, 2, \ldots, N(G^1)$.

G_i^2 = the identification of the i-th operation associated with the input processing function, $G_i^2 = 1, 2, \ldots, N(G^2)$.

G_i^3 = the identification of the i-th operation of the output processing function associated with initiative service outputs.

G_i^4 = the identification of the i-th operation of the output processing function associated with the responsive service outputs.

C. Relationship Between Variables

The next step in the characterization of the three groups of processes is to determine the relationship between the operations and information elements. The relationships can be presented in the form of two-way tables as indicated in previous sections.

$[H_j, G_i^1]$ = the binary relationship between the real world input elements H_j and the acquisition processing operation G_i^1.

$H_j \backslash G_i^1$	1	2	. . .	$H(G^1)$
1				
2	values of either "0" or "1"			
.				
.				
.				
$N(H_j)$				

$[I_r, G_i^2]$ = the binary relationship between the information input elements I_r and the input processing operation G_i^2.

$I_r \backslash G_i^1$	1	2	. . .	$N(G^2)$
1				
2	values of either "0" or "1"			
.				
.				
.				
N(I)				

$[Z_r, G_i^3]$ = the binary relationship between the stored input elements and the output processing operation G_i^3.

$Z_r \backslash G_i^3$	1	2	. . .	$N(G^3)$
1				
2	values of either "0" or "1"			
.				
.				
.				
N(Z)				

$[T_r, G_i^4]$ = the binary relationship between the responsive service outputs T_r and the output processing operation G_i^4.

$T_r \backslash G_i^4$	1	2	. . .	i	$N(G^4)$
1					
2	values of either "0" or "1"				
.					
.					
.					
N(T)					

D. Process Parameters

This section defines the manhour rates to be associated with the above parameters. The s ts of parameters to be estimated are as follows:

g_{ij}^1 = the estimated mean number of manhours associated with operation G_j^1 required to process a unit of information of type H_i.

$H_i \backslash G_j^1$	1	2	. . .	$N(G^1)$
1				
2	values of g_{ij}^1			
.				
.				
.				
N(H)				

g_{ij}^{2} = the estimated mean number of manhours associated with operation G_j^2 required to process a unit of information of type I_j.

$$
\begin{array}{c|ccccc}
I_i \diagdown G_j^2 & 1 & 2 & . & . & . \quad N(G^2) \\
\hline
1 & & & & & \\
2 & & \text{values of } g_{ij}^{2} & & & \\
. & & & & & \\
. & & & & & \\
. & & & & & \\
N(I) & & & & &
\end{array}
$$

g_{ij}^{3} = the estimated mean number of manhours associated with operation G_j^3 required to process a unit of information of type Z_i.

$$
\begin{array}{c|ccccc}
Z_i \diagdown G_j^3 & 1 & 2 & . & . & . \quad N(G^3) \\
\hline
1 & & & & & \\
2 & & \text{values of } g_{ij}^{3} & & & \\
. & & & & & \\
. & & & & & \\
. & & & & & \\
N(Z) & & & & &
\end{array}
$$

g_{ij}^4 = the estimated mean number of manhours associated with operation G_j^4 required to produce a unit of information of type T_i.

T_i \ G_j^4	1	2	.	.	.	$N(G^4)$
1						
2	values of g_{ij}^4					
.						
.						
.						
N(T)						

VII. COST PARAMETERS

A. Introduction

Preceding sections of the report have identified the sets of variables and their associated parameters required to quantitatively define the system. This section presents the cost parameters required to evaluate system operating costs.

Systems operating cost parameters are grouped in three categories:

1. Cost parameters associated with information materials inputs/outputs.
2. Cost parameters associated with system process functions.
3. Cost parameters associated with communications.

By utilizing the above cost parameters in conjunction with system parameters, the total system operating cost can be determined.

B. Materials Cost Parameters

This section identifies and defines the cost parameters, or coefficients to be estimated. Tabular forms for recording the data are also indicated.

r_{ij} = the estimated mean cost per unit of real world input of type H_j associated with project/mission D_i.

D_i \ H_i	1	2	.	.	.	N(H)
1						
2		values of r_{ij}				
.						
.						
.						
N(D)						

m^1_{ij} = estimated mean cost of material required in performing operation G^1_j to process a unit of information of type H_i.

H_i \ G^1_j	1	2	.	.	.	$N(G^1_j)$
1						
2		values of m^1_{ij}				
.						
.						
.						
N(H)						

m^2_{ij} = estimated mean cost of material required in performing operation G^2_j to produce a unit of information of type I_i.

I_i \ G^2_j	1	2	.	.	.	N(G)
1						
2		values of m^2_{ij}				
.						
.						
.						
N(I)						

m^3_{ij} = estimated mean cost of material required in performing operation G^3_j to produce a unit of information of type Z_i.

Z_i \ G^3_j	1	2	.	.	.	N(G)
1						
2	values of m^3_{ij}					
.						
.						
.						
N(Z)						

m^4_{ij} = estimated mean cost of material required in performing operation G^4_j to produce a unit of information of type T_i.

$T_i \backslash G^4_j$	1	2	.	.	.	$N(G^4)$
1						
2	values of m^4_{ij}					
.						
.						
.						
N(T)						

C. Process Cost Parameters

The process cost parameters to be estimated are as follows:

b^1_{ij} = estimated mean cost per manhour associated with operation G^1_j to process a unit of information of type H_i.

$H_i \backslash G^1_j$	1	2	.	.	.	$N(G^1)$
1						
2	values of b^1_{ij}					
.						
.						
.						
N(H)						

b_{ij}^{2} = estimated mean cost per manhour associated with operation G_{j}^{2} to process a unit of information of type I_{i}.

I_i \ G_j^2	1	2	.	.	.	$N(G^2)$
1						
2	values of b_{ij}^{2}					
.						
.						
.						
N(I)						

b_{ij}^{3} = estimated mean cost per manhour associated with operation G_{j}^{3} to process a unit of information of type Z_{i}.

Z_i \ G_i^3	1	2	.	.	.	$N(G_j^3)$
1						
2	values of b_{ij}^{3}					
.						
.						
.						
N(Z)						

b_{ij}^4 = estimated mean cost per manhour associated with operation G_{ij}^4 to produce a unit of information of type T_i

T_i \ G_j^4	1	2	.	.	.	$N(G^4)$
1						
2		values of b_{ij}^4				
.						
.						
.						
N(T)						

D. Communications Cost Parameters

The communications cost parameters to be estimated are as follows:

n_{ij} = the communications cost per unit distance for the E_j mode of communication associated with the i-th category of information elements.

E_j	1	2	. . .,	N(E)
$N_i = 1$				
$I_i = 2$				
$Z_i = 3$	values of n_{ij}			
$S_i = 4$				
$T_i = 5$				

VIII. SUMMARY OF SYMBOLS

A. User Community

1. Variables

$N(C)$ = the number of subject disciplines

$N(R)$ = the number of geographic regions

$N(D)$ = the number of projects/missions

C_r = the identification of the C_r discipline, $C_r = 1, 2, \ldots, N(C)$

R_s = the identification of the R_s geographic region, $R_s = 1, 2, \ldots, N(R)$

D_i = the identification of the D_i project/mission, $D_i = 1, 2, \ldots, N(D$

$N(K)$ = the number of direct service centers

K_o = the identification of "clearing house" center

K_r = the identification of the K_r direct service center, $K_r = 1, 2, \ldots, N(K)$

2. Parameters

$X(C_r, D_i)$ = estimated number of individuals associated with the i-th project/mission and the r-th subject discipline

$X(C_r, R_s)$ = estimated number of individuals associated with the r-th subject discipline and located in the s-th geographic region

$\beta^1(D_m, D_i)$ = estimated mean number of individuals associated with the i-th project/mission that are interested in the m-th subject discipline

$X(C_r)$ = estimated number of individuals associated with the r-th subject discipline

$D(K_o, K_r)$ = estimated distance from the clearing house center to the r-th service center

$D(K_r, R_s)$ = estimated distances from the direct service center to the centroid of the population of the s-th geographic region

B. Information Elements

1. Variables

$N(H)$ = the number of categories of real world inputs

$N(I)$ = the number of categories of input information elements

$N(Z)$ = the number of categories of stored information elements

$N(T)$ = the number of categories of responsive service outputs

H_j = the identification of the j-th type of real world input, $H_j = 1, 2, \ldots, N(H)$

I_r = the identification of the r-th type of input information element, $I_r = 1, 2, \ldots, N(I)$

S_r = the identification of the r-th type of initiative service output, $S_r = 1, 2, \ldots, N(S)$

T_r = the identification of the r-th type of responsive service output, $T_r = 1, 2, \ldots, N(T)$

2. Parameters

$Y(D_i, H_j)$ = the estimated mean number of real world inputs of type H_j generated by project/mission of type D_i per unit of time

a_{jr} = the estimated mean number of units of input information elements of type I_r derived from a real world input of type H_j

b_{jr} = the estimated mean number of stored information elements of type Z_r derived from an input information element of type I_j

c_{jr} = the estimated mean number of initiative service outputs of type S_r derived from a stored information element of type Z_j.

p_{jr} = the estimated percentage of the population of project/mission type D_r to receive service outputs of type S_j.

$\bar{p}_{jr}$ = the estimated mean number of requests for responsive outputs of type T_r per member of D_i project/mission per unit of time

C. Processing Functions

1. Variables

$N(G^1)$ = the number of operations associated with the acquisition processing function

$N(G^2)$ = the number of operations associated with the input processing function

$N(G^3)$ = the number of operations in the output processing function associated with initiative service outputs

$N(G^4)$ = the number of operations in the output processing function associated with responsive service outputs

G_i^1 = the identification of the i-th operation associated with the acquisition processing function, $G_i^1 = 1, 2, \ldots, N(G^1)$

G_i^2 = the identification of the i-th operation associated with the input processing function, $G_i^2 = 1, 2, \ldots, N(G^2)$

G_i^3 = the identification of the i-th operation of the output processing function associated with initiative service outputs

G_i^4 = the identification of the i-th operation of the output processing function associated with the responsive service outputs

2. Parameters

g_{ij}^1 = the estimated mean number of manhours associated operation G_j^1 required to process a unit of information of type II_i

g_{ij}^2 = the estimated mean number of manhours associated operation G_j^2 required to process a unit of information of type I_j.

g_{ij}^3 = the estimated mean number of manhours associated with operation G_j^3 required to process a unit of information of type Z_i

g_{ij}^4 = the estimated mean number of manhours associated with operation G_j^4 required to produce a unit of information of type T_i

D. Cost Parameters

1. Materials Cost Parameters

r_{ij} = the estimated mean cost per unit of real world input of type II_j associated with project/mission D_i

m_{ij}^1 = the estimated mean cost of material required in performing operation G_j^1 to process a unit of information of type II_i

m_{ij}^{2} = the estimated mean cost of material required in performing operation G_j^2 to produce a unit of information of type I_i

m_{ij}^{3} = the estimated mean cost of material required in performing operation G_j^3 to produce a unit of information of type Z_i

m_{ij}^{4} = the estimated mean cost of material required in performing operation G_j^4 to produce a unit of information of type T_i

2. Process Cost Parameters

b_{ij}^{1} = the estimated mean cost per manhour associated with operation G_j^1 to process a unit of information of type H_i

b_{ij}^{2} = the estimated mean cost per manhour associated with operation G_j^2 to process a unit of information of type I_i

b_{ij}^{3} = the estimated mean cost per manhour associated with operation G_j^3 to process a unit of information of type Z_i

b_{ij}^{4} = the estimated mean cost per manhour associated with operation G_{ij}^4 to produce a unit of information of type T_i

3. Communications Cost Parameters

n_{ij} = the communications cost per unit distance for the E_j mode of communication associated with the i-th category of information elements.

IX. CONCLUDING REMARKS AND RECOMMENDATIONS

A. Concluding Remarks

The identification and definition of the generalized sets of variables and parameters presented herein represents the first step in the development of a detailed and tailored methodology for the quantitative evaluation of alternative LINC systems. The methodology and subsequent mathematical models will permit precision evaluation of alternative LINC systems in terms of system cost and value/effectiveness.

The quantitative evaluation process will require the use of two models which we have identified as the "evaluation model" and the "descriptive model". The development of the evaluation model would be based upon the

1. the detailed objectives of the INFORMATION-SYSTEM PROGRAM FOR THE LANGUAGE SCIENCES and
2. the outputs of the descriptive model.

The descriptive model would characterize the alternative LINC systems in terms of the specific operational processes that govern the cause and effect relationships as described in the IDC report, "A Methodology for the Analysis of Information Systems". The variables and parameters identified and defined herein are inputs to the descriptive model.

In descriptive terms, the variables represent those elements of the system that are controlled by system designers and parameters represent those elements of the system which are not controlled by system designers. Alternative systems designs are erected by choosing a particular subset of variables. The variables associated with systems are deterministic in nature and parameters are probabilistic and, consequently, must be estimated making use of the best available data.

B. Recommendations

As a result of this study, five (5) recommendations suggest themselves in the following order:

1. Specification of System Variables

   Based upon the results of CAL's SURVEY-AND-ANALYSIS STAGE of the study program, listings of the variables defined in this report should be compiled.

2. Design Data Forms

   Based upon the resulting lists of variables, data forms should be designed to facilitate the recording and estimation of parameter values.

3. Data Reduction

   Procedures should be developed to estimate the parameter values identified in this report making use of best available data.

4. Develop Evaluation Model

   Based upon objectives to be developed by CAL, a detailed evaluation model should be developed to aid in the evaluation of alternative systems.

5. Tailor IDC Descriptive Model

   The IDC model should be tailored to meet CAL's specific evaluation requirements and time schedule.